International Journal of Agricultural
Science and Research (IJASR)
ISSN(P): 2250-0057; ISSN(E): 2321-0087
Vol. 7, Issue 2, Apr 2017, 541-546

RESPONSE OF RICE CROP UNDER ELEVATED CARBON DIOXIDE CONCENTRATION WITH AZOLLA TREATMENT

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ABSTRACT

Azolla is known for efficiently sequestering CO_2 without the requirement of soil based nitrogen source. This makes azolla an important green manuring crop in rice based farming systems. Extensive studies have established that elevated CO_2 profoundly effects growth and development, physiology and productivity in rice plant. This study was conducted to determine the effect of elevated CO_2 on rice supplemented by azolla as nitrogen source. Rice was grown under different CO_2 concentrations and azolla treatments in environment controlled chambers (ECC) during June to November 2016. Rice plants responded mostly positively to elevated CO_2. Plant Dry weight was found to increase except at 700 ppm. Likewise other parameters responded in the same manner. Azolla treated plants were higher in terms of dry weight against those without the ferns. Panicle length was found to be higher in higher CO_2 environment. Same was found in case of test weight as in general, growth and yield of rice tent to increase with elevated atmospheric CO_2 concentration. Heading time was shortened but maturity extended with elevated CO_2 irrespective of azolla treatment. From these result we conclude that these effects of elevated CO_2 to some extent is positively affected by incorporating rice with azolla.

KEYWORDS: Elevated CO_2, Azolla, Rice & Seed Weight

Received: Mar 08, 2017; **Accepted:** Mar 28, 2017; **Published:** Apr 10, 2017; **Paper Id.:** IJASRAPR201768

Original Article

INTRODUCTION

Azolla is considered as a super organism due to its inherent potential to sequester atmospheric CO_2. It is unique because of its immense ability to sequester atmospheric CO_2 without the requirement of soil-based Nitrogen source. It is established from Arctic Coring Expedition studies that "Arctic *Azolla* Event" has a big impact in reducing greenhouse gases, ending the greenhouse climate that had prevailed for hundreds of millions of years during the middle Eocene. *Azolla* forms a nitrogen-fixing symbiosis with the cyanobacterium *Anabaena azollae*, which is present in the leaf cavity of these aquatic ferns (Watanabe 1982, Spore 1992) [15]. Its capacity to fix atmospheric nitrogen easily surpasses other biological systems. This quality has been recognised for some time and put in to good use for agronomical purposes. Most of *Azolla* research has been focussed on its nitrogen sequestration potential relating to the fertilization in Rice based farming systems (*Azolla* Foundation).

The ever rising atmospheric CO_2 in the past recent decades have led some of us to re-evaluate the amount of carbon signature that we contribute from all realm of livelihood. Agricultural practices have its fair share in contributing one third of all human caused greenhouse gas emissions which rises concern that reducing agriculture's carbon footprint is central to limiting climate change (Nature 2017 Feb. Natasha Gilbert) [9]. *Azolla* is the most commonly used green manuring plant in rice-based farming system due to its prolific growth rate, ability to fix nitrogen and scavenge nutrients from soil. Its ability to sequester CO_2 is twice the biomass in 2 to 5

days under ideal conditions (Watanabe *et al*. 1989) [14]. These facts make it an ideal candidate plant for green manuring in wetland farming systems. When used as green manuring agent *Azolla* fulfills more than half of the nitrogen requirement to the rice crop and besides providing nitrogen it is beneficial in wetland rice fields for preventing rise in pH, reducing water temperature, curbing NH3 volatilization, suppressing weeds and mosquito proliferation (Pabby *et al*. 2004) [10].

This study is emphasized on investigating possibility of using *Azolla* in rice ecosystem as nutrient supplement under different levels of elevated CO_2. The main objective of this work was to study the effect of elevated CO_2 on rice crop growth and development supplemented by *Azolla* as green manure.

MATERIALS AND METHODS

The experiment was conducted in between July to November 2016 inside environmental control chamber (Make: Genesis Technologies, Maharashtra) at Stress Physiology Laboratory, Assam Agricultural University, Jorhat, India. For this experiment six Environmental Control Chambers (ECC) and two ambient condition chambers (ACC). These chambers were separated into two set, each consisted of three ECC and one ACC. First set consisted of pots with rice grown without *Azolla* and second set consisted of rice grown with *Azolla*. Both set were treated with atmospheric carbon dioxide separately in six environmental controlled chambers at concentrations with 400 ppm, 500 ppm, 700 ppm and ambient condition chambers remain at 380 ppm (Ambient CO_2 concentration). The carbon dioxide inside the growth chambers was enriched for a daily period of 6 hours from 14 days after transplanting for a period of 45 days. 21 days old four rice seedlings of variety *Luit* were transplanted in each earthen (40 cm height and diameter) pot and placed inside the different growth chambers. The pots were filled with topsoil, sand and cow dung (1:1:1) in which combination of organic and inorganic fertilizers applied at the rate 40:20:40 of N: P_2O_5: K_2O respectively. The second set of ECC was inoculated on each pot with *Azolla carolliniana* at the rate of 0.012 kg pot^{-1} (2 ton ha^{-1}) one week after transplanting as per recommendation in the practice and package. The carbon dioxide inside the growth chambers was enriched for a daily period of 6 hours from 14 days after transplanting for a period of 45 days. The growing conditions were controlled during the entire growing period automatically via control system equipped with temperature thermostat and humidity controls in the chambers. Plant heights were recorded at 100% heading stage. Total dry weight was measured at harvest along with five panicle dry weight. 1000 seeds weight test were measured for test weight according to ISTA. Days to 50% flowering, Days to maturity were observed but counting the days after planting.

RESULTS

Plant height responded the same throughout the treatments which implies that elevated CO_2 do not affect plant height of rice. An average increase in plant height resulted due to *Azolla* treatment and plants grown with *Azolla* were found to be more benefitted.

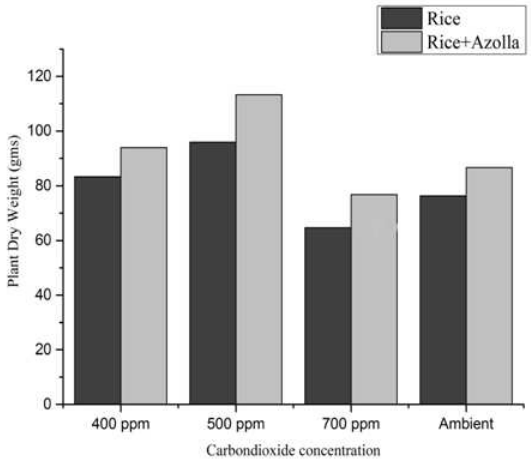

Figure (a): Effect of Elevated CO_2 on Plant Dry Weight

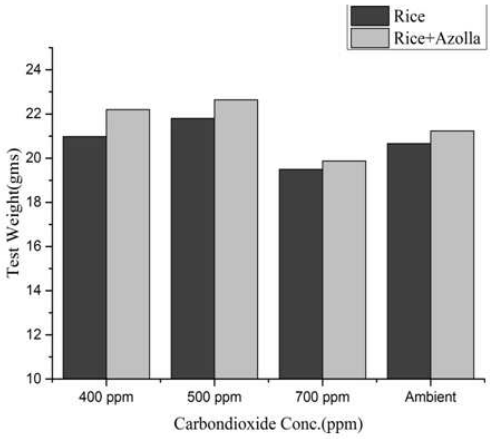

Figure (b): Effect of Elevated CO_2 on Test Weight

From Figure a. it is evident that highest total dry weight (TDM) was observed in case of 500 ppm with *Azolla* and lowest being 700 ppm without *Azolla*. Condition where *Azolla* is incorporated stood out for having the higher TDM than without *Azolla.* The treatment of 500 ppm CO_2 remained highest in the respective conditions. There were clear interaction between CO_2 and *Azolla* treatment in dry weight of whole plants. At 700 ppm CO_2 plant relatively performed poor in spite of *Azolla* supplementation supporting the fact that higher CO_2 hamper poor TDM accumulation.

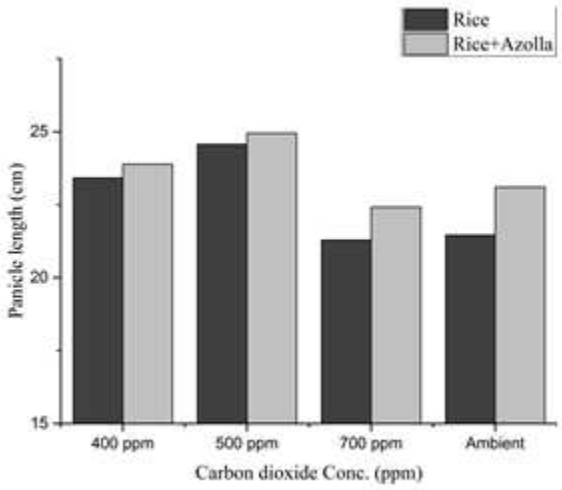

Figure (c) Effect of Elevated CO_2 on Panicle Length

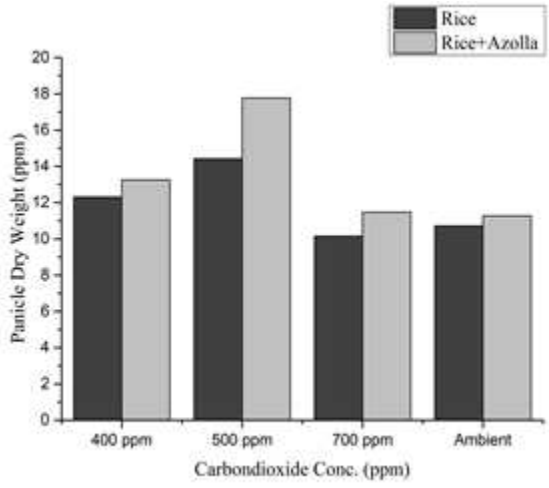

Figure (d): Effect of Elevated CO_2 on Panicle Dry Weight

Higher CO_2 concentration negatively affects the grain weight as 700 ppm CO_2 is found to have the minimum seed weight even when nitrogen is being supplemented by *Azolla*. There was a slight interaction between CO_2 and *Azolla* leading to individual grain weight significantly increased (by 4.8%) on average. Seed weight test was recorded to be highest in treatment of 500 ppm CO_2 with *Azolla* among the treatments (Figure b). Panicle length and weight were positively affected due to both CO_2 and *Azolla* treatment both individually as well as interactively (Figure c and Figure d). A significant decrease was observed only in case of 700 ppm CO_2 treatments.

Higher CO_2 at 700 ppm was found to accelerate heading in comparison to Ambient CO_2 concentration. A small but significant decrease in heading time was observed in condition where *Azolla* was incorporated. All the elevated CO_2 treatment was found to hasten heading but slightly delayed in than ambient CO_2. The faster heading is more pronounce in

those treatments grown without *Azolla.* In contrary to this hastening of heading, plants grown under elevated CO_2 responded by delay in attaining maturity. Maturity is delayed the most in case of high CO_2 concentration. This delay is accentuated by the presence of *Azolla* in the growing condition.

DISCUSSIONS

Experiments on effect of elevated CO_2 has not reported increase in plant height which suggests that plant height in rice is not affected by elevated CO_2. However treatment of *Azolla* did positively affected rice plant by increasing plant height by modifying the plant habit which is due to nitrogen supplementation (Ziska *et al.* 2001,2006) [17&18], (Ahmed, Mahtalat, *et al.*2005) [19]. Not only *Azolla* but CO_2 also significantly affected total plant dry weight in rice. This is due to photosynthetic enhancement and prolonged photosynthates accumulation period. The increase in panicle length and panicle weight is also supported by photosynthetic enhancement and prolonged photosynthates accumulation. Seed weight is increased due to elongated assimilate partitioning time and increased photosynthetic rates (Nakotomo *et al.*) [8]. The net whole plant dry weight increase during treatment was due to both ear formation and stem biomass accumulation (Cheng Weiguo, *et al.*2009) [3]. Elevated CO_2 substantially increased grain yield of rice, and this is partly due to increases in tiller numbers (Kim *et al*., Razzaque *et al*.2010) [5][11]. Similar results have been reported elsewhere (Kim *et al*. 2001) [4]. Filling rate also positively influence seed weight, kernel weight (C. Zhu *et al*) [2]. The accelerated flowering response in rice is partially understood (Springer 2007) [13] and has been suggested that several factors such as carbon metabolism. As plants grown on elevated carbon dioxide accumulates excess sugar in the plant parts (Long *et al*., 2004) [6] which may be one possible mechanism through which elevated CO_2 may be influencing flower timing. Lawler and Mitchell (1991) squarely attributed that elevated CO_2 increase in grain yield to the production of larger number of seed numbers, panicle weight, tillers. Baker *et al.* (1990) [1] reported that in rice, increase number of panicle is entirely responsible by on elevated carbon dioxide. Delayed maturity in elevated CO_2 is brought about by increase in flowering period and leaf area duration. Increased nitrogen sources had been found to enhance vegetative stage. The synergistic effect of these treatment and conditions is likely to cause the delay even further Roux F. (2006) [12].

CONCLUSIONS

It can be partially concluded from this experiment that incorporating Azolla in rice cultivation proved to increase some of these characteristics related to dry matter yield that eventually increase the overall yield even under the influence of different CO2 concentrations. It is also evident that different CO2 concentrations have a profound effect on rice growth and yield. Thus incorporating azolla in rice cultivation will be beneficial for rice yield, soil and the farming community even under the predicted elevated atmospheric CO2 conditions in near future.

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